THE WEATHER AND CIRCULATION OF FEBRUARY 1959

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1. HIGHLIGHTS

February 1959 was a month of marked variability in weather across the United States, as manifested partly by weekly alternations of above and below normal temperatures and of record maximum and minimum temperatures (for the date) at some stations in the East (table 1). This month was featured by the highest daily sea level pressures (up to 1053 mb.) on record at some stations in the upper Mississippi Valley at the beginning of the month. It was also highlighted by a disastrous storm on the 9th and 10th, accompanied by tornadoes, one of which took the lives of 21 persons in St. Louis, Mo., early on the morning of the 10th, with hundreds injured and millions of dollars in property damage. In addition to tornadoes, this storm included a wide variety of severe weather, such as blowing dust, glaze, high winds, floods, snow, and thunderstorms. It brought a repeat of flood conditions requiring evacuation to sections of Indiana and Ohio, where only 20 days before similar disaster struck on January 21 [1].

On a monthly basis few records were broken, although near-record snowfall occurred at some stations, such as Missoula, Mont., Rochester, Minn., Green Bay and La Crosse, Wis., and also at the higher elevations in the West, such as Blue Canyon and Mt. Shasta, Calif., Sexton Summit, Oreg., and Ely, Nev. The month was cold and snowy in parts of the Northeast such as Rochester, N.Y., and Burlington, Vt., but, by way of contrast, Binghamton, N.Y. had its lightest snowfall in 40 years. This was the coldest February in over 20 years in many parts of the northern border States from Montana to Michigan (and the coldest winter season as well). It was a very cloudy and rainy month in the Gulf States with Brownsville, Tex., reporting rain on 22 days and Lake Charles, La., reporting only one clear day during the month.

TABLE 1.—*Some reversals of daily record temperatures (°F.) during February 1959*

	Maximum	Date	Minimum	Date
Newark, N.J.	49	5th	8	2d
Schenectady, N.Y.	46	5th	−4	12th
Birmingham, Ala.	78	14th	18	21st
Richmond, Va.	73	10th	13	21st

2. CONTRAST WITH PREVIOUS MONTHS

February 1959 contrasted sharply with its predecessor, January, as well as with February of 1958. In the eastern half of the country, except New England, a general warming, relative to normal, occurred from the cold that had prevailed during January, and marked cooling in the West ended the extreme warmth that had existed there in January. Few extremes of temperature developed, however.

This month was also a welcome contrast in the eastern United States, particularly in Florida, to February of the preceding year, which had been the coldest February on record in the southeastern quarter of the country [2]. As might be expected, the axis of maximum westerly winds at 700 mb. was considerably farther north over the Western Hemisphere this February than a year ago, when the great index cycle of 1958 was in its most depressed state with the westerlies at 32° N. or 6° south of normal [2]. This February the westerly wind axis remained persistently near 43° N., or about 5° north of

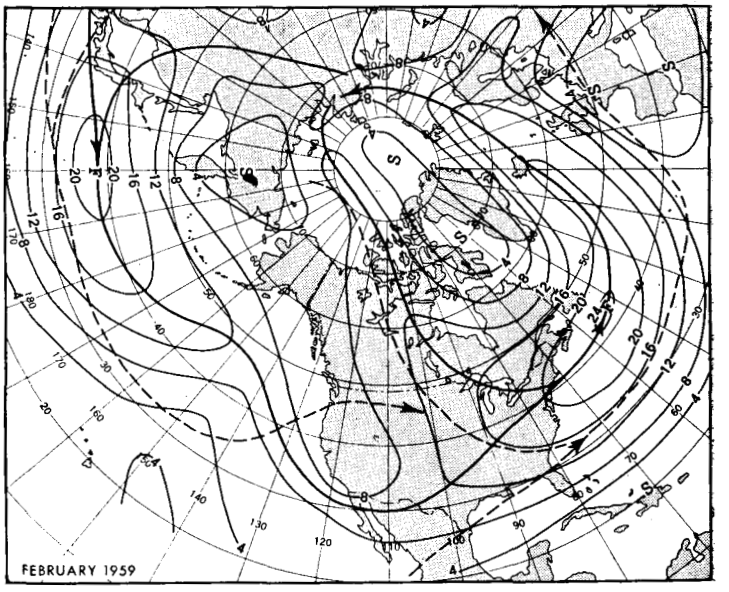


FIGURE 1.—Mean 700-mb. isotachs for February 1959 in meters per second. Solid arrows are axes of maximum speed (jets). Dashed lines are jet axes in February 1958. Important feature is confluence of jets in the Northeast.

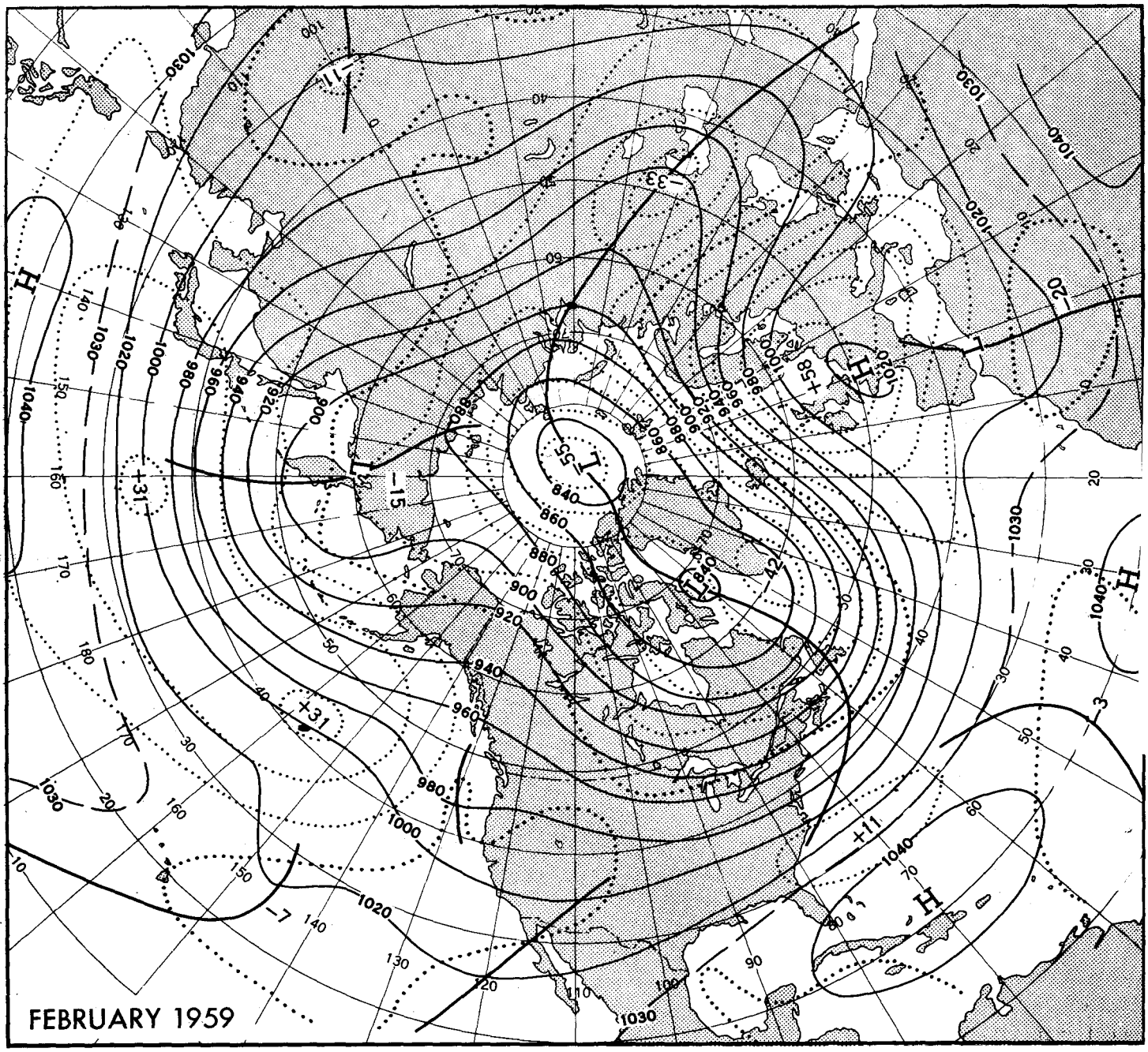


FIGURE 2.—Mean 700-mb. height contours (solid) and departures from normal (dotted) (both in tens of feet) for February 1959. Large negative anomalies in polar regions were accompanied by an almost circumpolar ring of positive anomalies at middle latitudes in the Western Hemisphere, resulting in contracted circumpolar westerlies—an almost complete reversal from February 1958.

normal, with no significant fluctuations in speed throughout the month. This is somewhat surprising, considering the intra-monthly variability of the weather and circulation over the United States to be discussed below. Figure 1 shows the distribution of 700-mb. mean winds for this February, with axes of maximum speed delineated. The maximum speed axes for February 1958 are also given to show the marked northward displacement this year over most of the hemisphere in comparison with a year ago. In the western States the axis was farther south this year, reflecting cooler conditions in this area in contrast to the extreme warmth of February a year ago.

3. MONTHLY MEAN CIRCULATION AND WEATHER

Figure 2 shows the characteristics of this month's mean circulation. The large-scale waves were generally close to their normal positions, with the Asiatic coastal trough much weaker than normal and the Kamchatka center of action about normal in intensity. The gradient of height departures from normal in the northern part of the North Pacific shows that the westerlies in this area were stronger than normal. This may have contributed to the fact that the trough in the Maritime Provinces of Canada was slightly east of its normal position. Above normal northwesterly flow over Canada was associated with a deeper

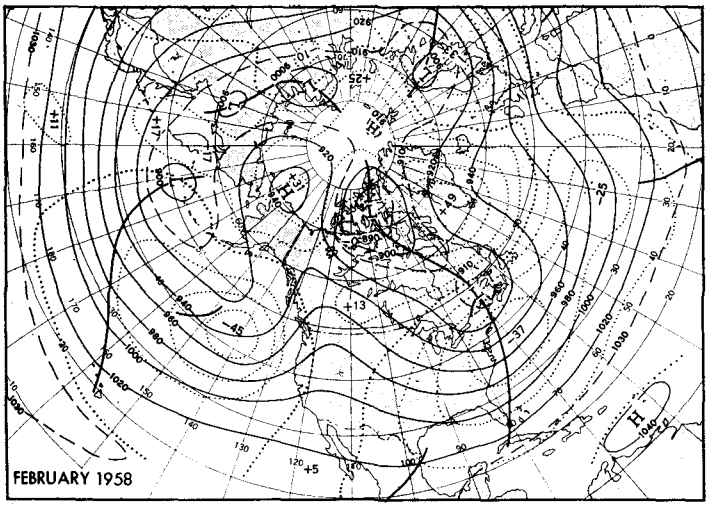


FIGURE 3.—700-mb. height contours (solid) and departures from normal (dotted) for February 1958. Note expanded circumpolar westerlies due to positive anomalies in polar regions with negative anomalies to south.

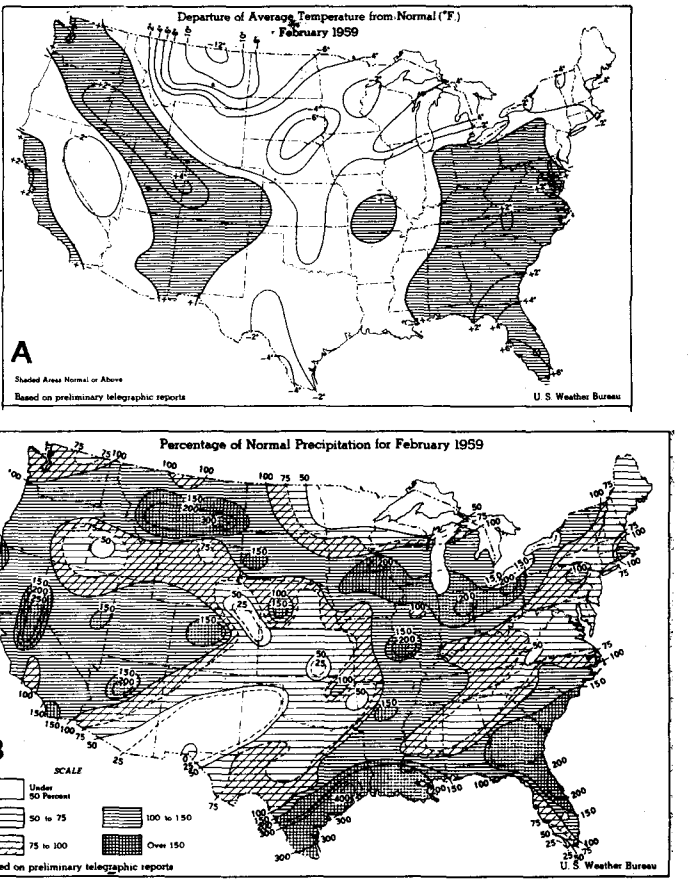


FIGURE 4.—(A) Departure of average surface temperature (°F.) from normal for February 1959. (B) Percentage of normal precipitation for February 1959. (From *Weekly Weather and Crop Bulletin, National Summary*, vol. XLVI, No. 9, March 2, 1959. and No. 10, March 9, 1959).

than normal center of action near Baffin Island. The most prominent abnormalities of the monthly circulation were the extremely deep polar vortex, 550 feet below normal, and the intense and persistent blocking High over western Europe, averaging 580 feet above normal for the month. Between the European block and the polar Low an anomalous southwesterly gradient of almost 1,000 feet existed, on the average, between the eastern coast of Greenland and the British Isles. This was expressed as a remarkably strong southwesterly jet in the North Atlantic across Iceland (fig. 1).

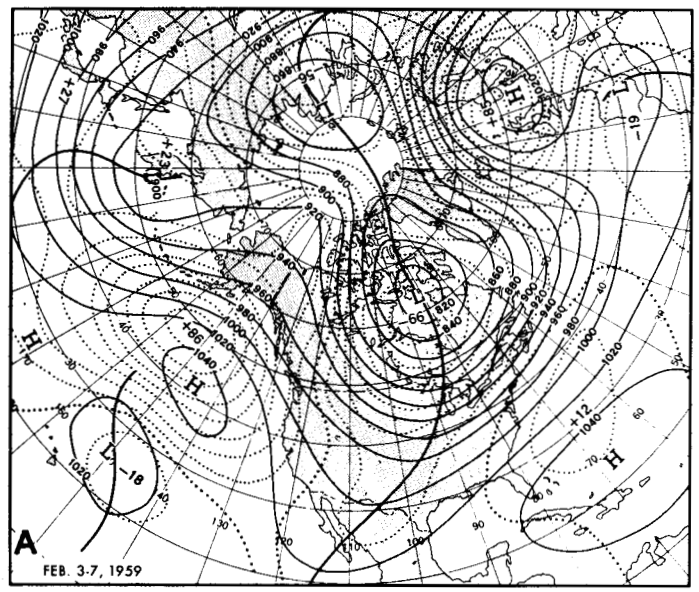
The subtropical westerlies at 700 mb. were weaker than normal during the month throughout the Western Hemisphere, especially in the Pacific where they were 6 to 8 meters per second below normal. At sea level the subtropical easterlies were stronger than normal, bringing heavy precipitation to windward locations in Hawaii. Hilo, a windward station which normally has a prevailing southwest wind due to local peculiarities, this month reported a prevailing wind direction of east-northeast, averaging about 3 miles per hour above normal, with a resulting rainfall of 3.61 inches more than normal.

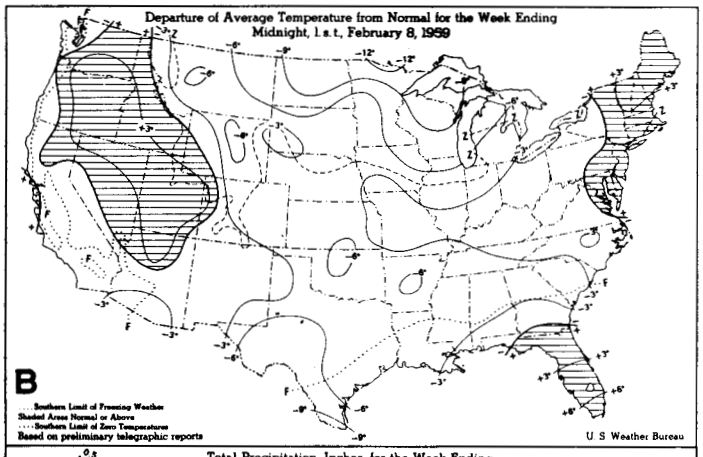
In contrast to the marked persistence of the large-scale circulation from December 1958 to January 1959 [1], the circulation this month showed a dramatic reversal from the earlier state, particularly as portrayed by the monthly mean 700-mb. height anomalies. The extensive band of positive anomaly from the Bering Sea to the Denmark Strait in January gave way to equally large negative values this month, with height anomalies decreasing almost 1,100 feet over southern Greenland. Negative height departures of January were also reversed this month in the eastern Pacific, eastern United States, and in Scandinavia where a strong block became entrenched early in the month. To complete the reversal, above normal heights in the southwestern United States gave way to negative departures this month.

The similar contrast of this month with its counterpart in 1958 may be seen by comparing figures 2 and 3, and, in particular, the height departures from normal. It is of interest, in this connection, that February of 1958 was quite similar throughout the hemisphere to January 1959, except that the below normal heights and temperatures in the East and Southeast were less intense in January 1959.

Figure 4 summarizes the monthly departures of temperature and precipitation from normal. The northwesterly flow along the northern border States, together with snow cover, kept this area well below normal. Montana was the coldest region, relative to normal, over the whole of North America, with some sections of Quebec Province running a close second. Nitchequon and Seven Islands, Quebec, averaged 10° below normal due to strong northerly flow associated with the much deeper than normal trough in Davis Strait. The warmest section of the continent, relative to normal, was Aklavik, N.W.T. which averaged 12° above normal under the influence of faster than normal southwesterly flow.

A weak ridge kept the eastern sections of the United States, from the Ohio Valley southward, relatively warm for this time of year, with Florida the warmest section of the country on both a relative and absolute basis. Fort





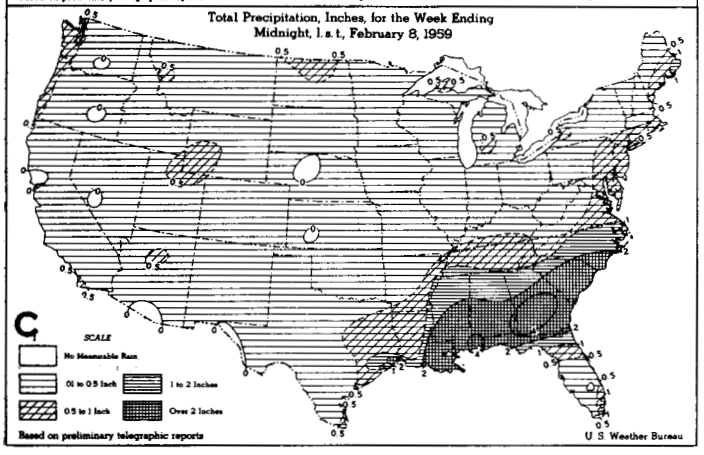
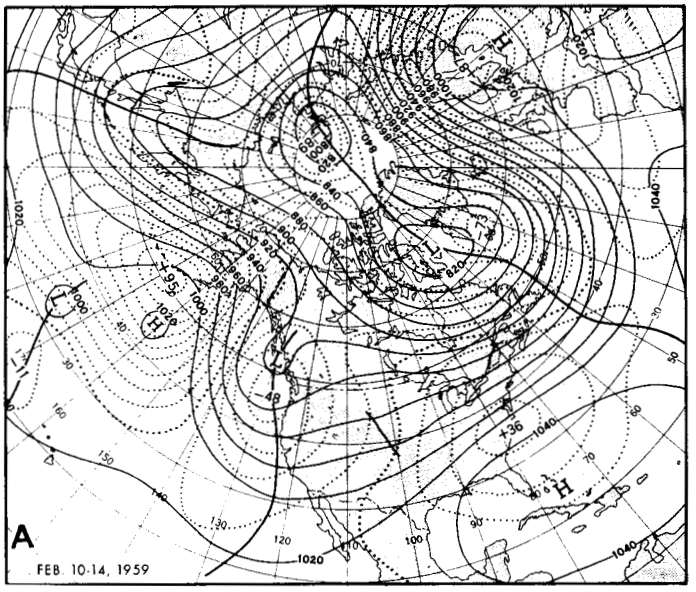
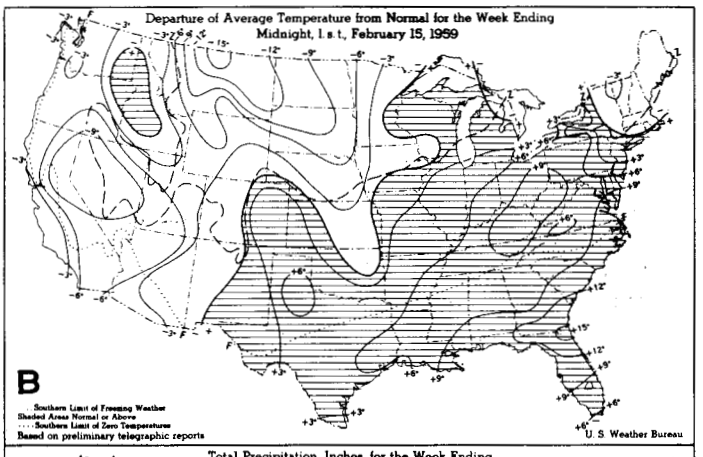


FIGURE 5.—(A) 5-day mean 700-mb. contours (solid) and height departures from normal (dotted) (both in tens of feet) for February 3–7, 1959. (B) Departure of average surface temperature from normal (°F.), and (C) total precipitation (inches) for the week ending February 8, 1959. (From *Weekly Weather and Crop Bulletin, National Summary*, vol. XLVI, No. 6, Feb. 9, 1959.)





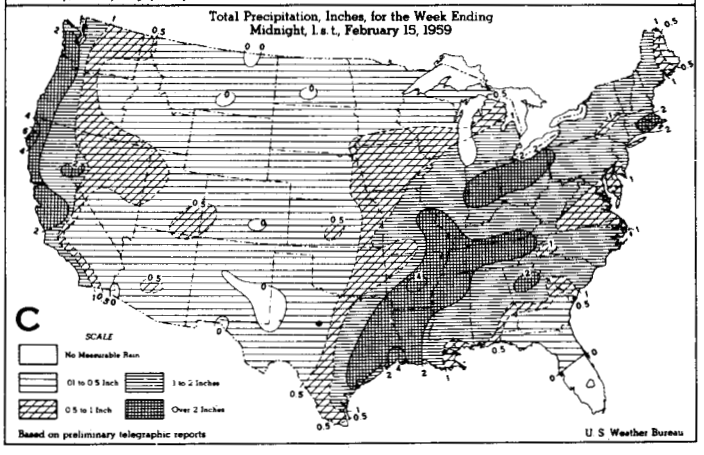


FIGURE 6.—(A) 5-day mean 700-mb. contours (solid) and height departures from normal (dotted) (both in tens of feet) for February 10–14, 1959. (B) Departure of average surface temperature from normal (°F.), and (C) total precipitation (inches) for the week ending February 15, 1959. (From *Weekly Weather and Crop Bulletin, National Summary*, vol. XLVI, No. 7, Feb. 16, 1959.)

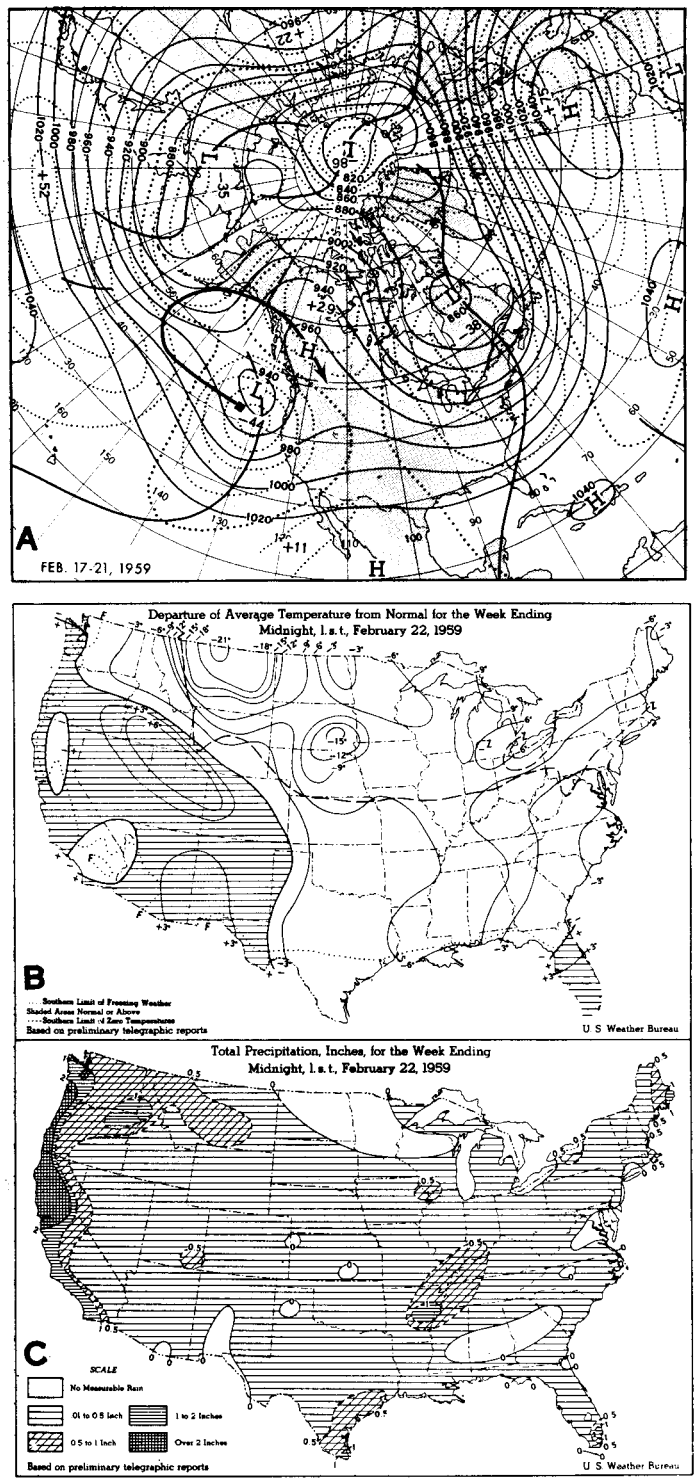


FIGURE 7.—(A) 5-day mean 700-mb. contours (solid) and height departures from normal (dotted) (both in tens of feet) for February 17–21, 1959. Heavy solid arrow is the track of the eastern Pacific anticyclone from the beginning of the month. (B) Departure of average surface temperature from normal (°F.), and (C) total precipitation (inches) for the week ending February 22, 1959. (From *Weekly Weather and Crop Bulletin, National Summary*, vol. XLVI, No. 8, Feb. 23, 1959.)

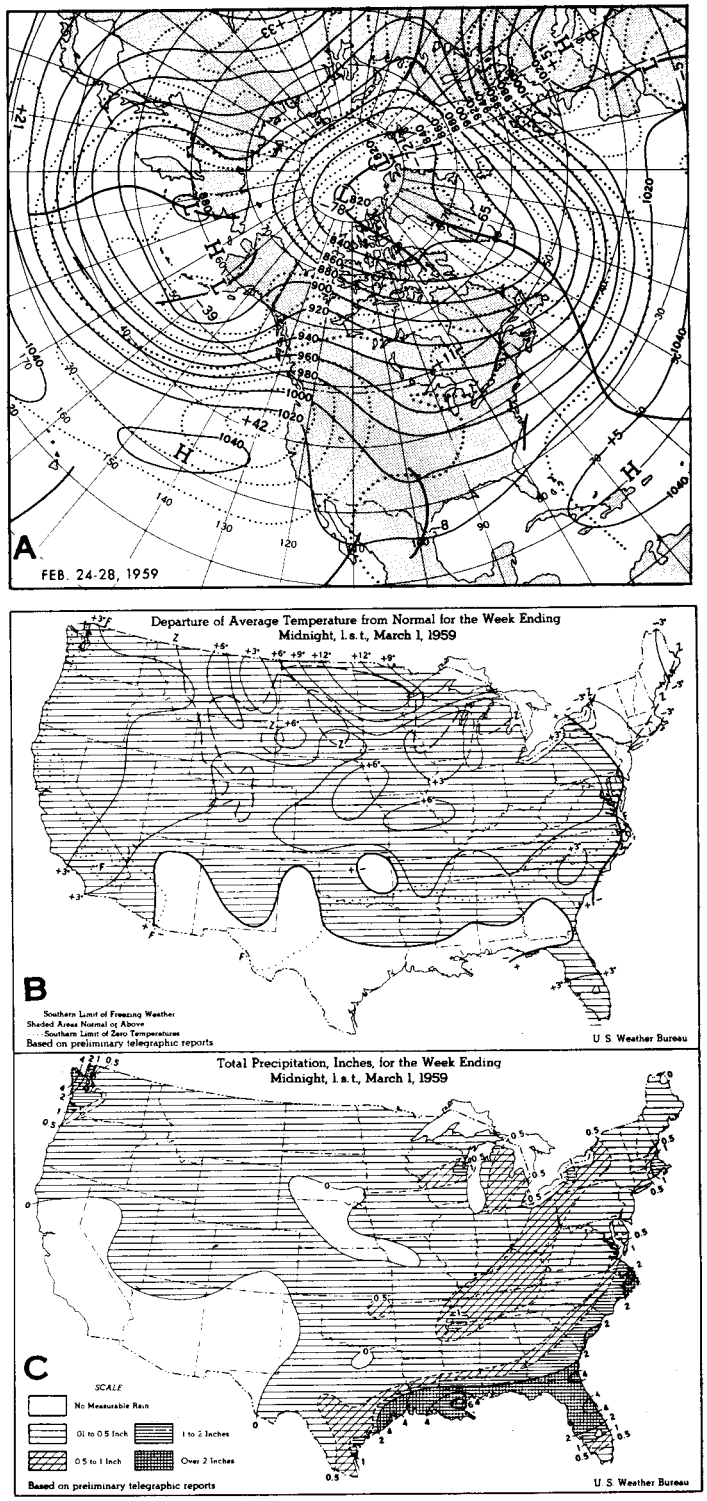


FIGURE 8.—(A) 5-day mean 700-mb. contours (solid) and height departures from normal (dotted) (both in tens of feet) for February 24–28, 1959. (B) Departure of average surface temperature from normal (°F.), and (C) total precipitation (inches) for the week ending March 1, 1959. (From *Weekly Weather and Crop Bulletin, National Summary*, vol. XLVI, No. 9, March 2, 1959.)

Myers reported the second warmest February on record. Strong trough conditions in the West during the middle two weeks kept the extreme Southwest cooler than normal, except along the immediate coast of central and southern California where the major cities continued to report above normal conditions. Los Angeles airport appeared to be the warmest point on the coast, reporting an average temperature 3.2° above normal, in contrast to downtown Los Angeles where the temperature averaged 0.1° below normal. A somewhat similar condition existed at San Francisco, where temperatures at the airport averaged 2.4° above normal and at the downtown office only 0.5° above normal. Sea surface temperature anomalies at Santa Monica and Avila Beach averaged about 3.0° above normal. This was consistent with the air temperature anomalies on the immediate coast, except at Santa Maria where surprisingly, the air temperatures averaged 1.2° below normal.

Heavy precipitation amounts along the Gulf coast and in southeastern United States were produced by persistent southwesterly winds which lifted moist Gulf air over the polar front. Somewhat similar conditions prevailed in Montana, where the Arctic front was overrun by moist Pacific air. Above-normal precipitation in the middle Mississippi and Ohio Valleys was associated with recurrent confluence and the related track of migratory cyclones in this area. Heavy precipitation in the West was due to persistent storminess during the middle two weeks associated with the very deep mean trough along the Pacific coast.

Dry conditions prevailed in the central Plains and southern Rockies, primarily due to downslope effects, while the relatively dry area from the foot of the Appalachians northeastward to New England was a manifestation of post-trough desiccation. Below normal amounts in the upper Mississippi Valley were largely the result of dry northerly flow prevailing throughout the month.

4. WEEK-TO-WEEK VARIABILITY

The variability of the weather and circulation within the month is perhaps best illustrated by the observed weekly temperature and precipitation anomalies and 5-day mean 700-mb. contours and height anomalies centered near the middle day of each week (figs. 5–8). The month was marked by a migratory anticyclone in the Gulf of Alaska and western Canada, while persistent blocking dominated western Europe. Retrogression in the first part of the month resulted in new trough formation, and progression was the rule toward the end of the month when the westerlies speeded up to their maximum of 13 m.p.s., averaged over the Western Hemisphere at temperate latitudes.

An important aspect of the mean circulation in the first part of the month was retrogression of the eastern Pacific anticyclone, which subsequently recurved eastward along the southern coast of Alaska, thence southeastward into British Columbia by the 3d week, as shown by the trajectory in figure 7A.

Another important feature of the mean circulation during the month was the gradual migration of the center of action in northern Siberia toward the North Pole. This was brought about in part by the persistent ridging tendency over the Lake Baikal area due to persistent southerly flow out of the deep trough in the Caspian Sea. The latter was maintained in great strength throughout the month by flow emanating from the blocking High over western Europe. The tendency toward a polar vortex eventually resulted in fast westerlies around the entire hemisphere with spring-like weather over almost all the United States at the end of the month. The week-to-week evolution is summarized briefly as follows:

During the first week, retrogression of the mean High in the northeastern Pacific favored the development of a new trough near the west coast (fig. 5A), in a manner that has been observed previously [3].

During the second week, the development of the west coast trough, which resulted in heavy precipitation along the coast, produced a major readjustment over North America. The trough which had dominated the midsection was forced eastward to the Davis Strait. As a result strong warming occurred in the eastern United States, and heavy precipitation spread in the confluent flow from the lower Mississippi Valley to New England (fig. 6).

During the third week, a sharp recurvature in its trajectory carried the Gulf of Alaska High eastward into western Canada (fig. 7A). The Low in the Pacific Northwest remained cut off and stationary, with heavy precipitation continuing along the west coast. The advent of the block into western Canada produced a relaxation of the temperate westerlies over North America, a condition favorable for retrogression of the trough from the western Atlantic to the east coast of the United States. In addition, flow from the stronger than normal ridge in western Canada helped transport cold Canadian air southward into the retrograding trough near the east coast. This resulted in a reversal of the temperature regime in the eastern United States from the warmth of the second week. With northerly wind components over much of the country, precipitation was mostly light except along the west coast (fig. 7 B and C).

In the fourth week, the center of action in the Siberian Arctic crossed the Pole and, together with the collapse of the ridge in western Canada, produced a strong zonal wind regime. This favored progressive waves in the Western Hemisphere, with warm and dry air flooding much of the United States, except near the Gulf coast which was wet and cool (fig. 8).

5. CYCLONE AND ANTICYCLONE TRACKS

This month there were two preferred tracks of anticyclones from northwestern Canada, in close agreement with the normal tracks [4], one just north of the Great Lakes and across New England, and the other south of the Lakes and across the Virginia Capes. In all, 10 Highs crossed the east coast during the month, evenly divided

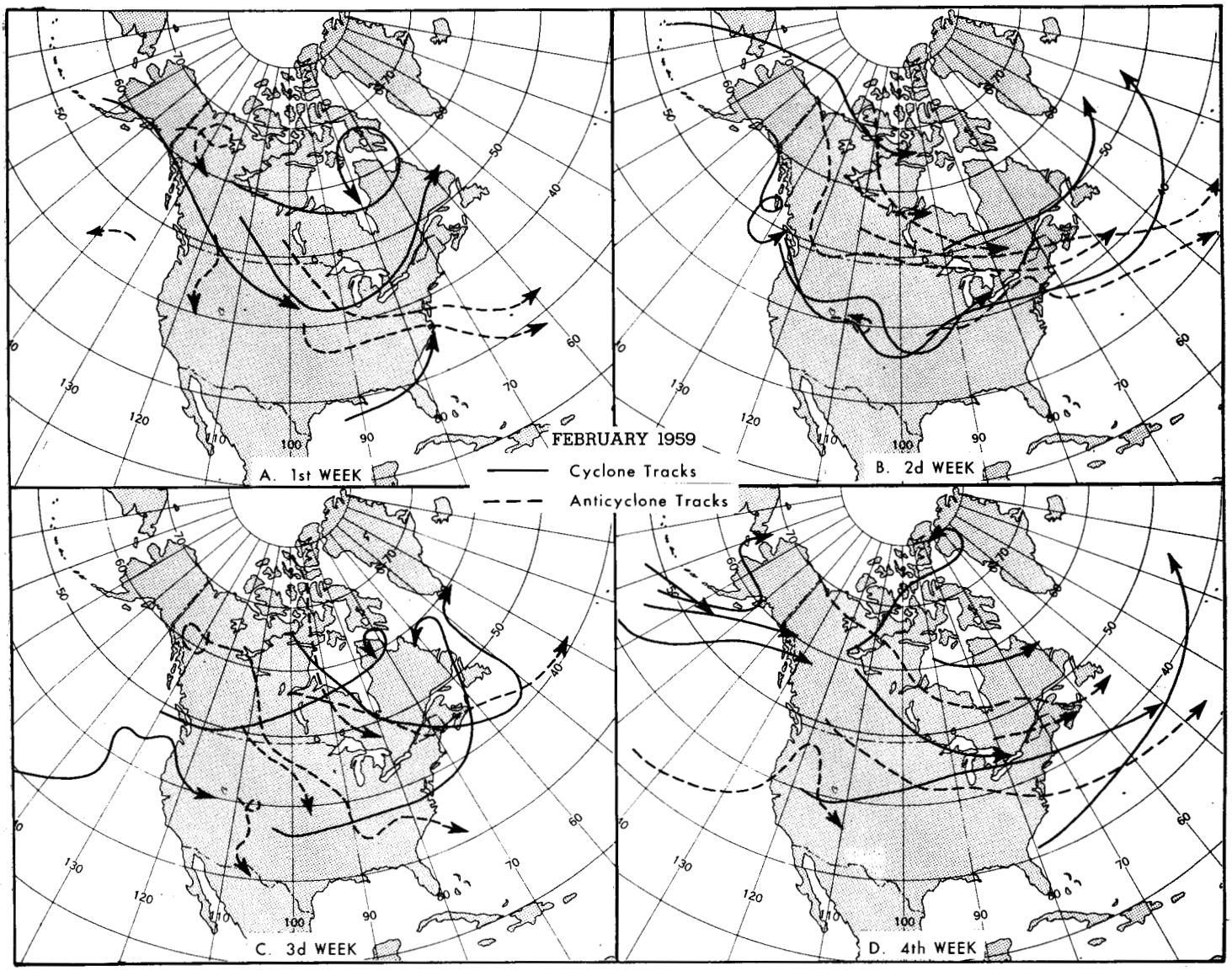


FIGURE 9.—Daily tracks of migratory cyclones (solid) and anticyclones (dashed) at sea level by weeks. Each track begins at approximate location of center at beginning of week, or at location of formation, and ends at approximate position at end of week, or at location of disappearance. Tracks may be compared with mean flow in figures 5A–8A.

between the two tracks. The most frequent interval between Highs crossing the coast was 2 days but with intervals in the second half of the month quite variable; e.g., a 6-day interval in the 3d week. This was the coldest period of the month in the eastern and central United States as a cold High from the Yukon, moving steadily southward, took about a week to arrive at the North Carolina coast, producing some record minimum temperatures en route, such as −30° at Huron, S. Dak. on the 19th and 13° at Richmond, Va., on the 21st.

Cyclonic systems originated over a wide range of latitudes in the western part of North America, with the majority converging toward the Great Lakes region and thence moving across southern New England, in general agreement with the prevailing confluent flow of the monthly circulation (fig. 2). The principal track crossed the east coast near 40° N., well to the south of the normal February track.

A comparison of weekly tracks in figure 9 with the corresponding week's mean circulation in figures 5A—8A shows that generally the cyclones followed the mean flow northward on the east side of the mean troughs toward the centers of action, while the Highs glanced off toward the subtropical Highs.

A brief inspection of the weekly tracks shows that in the first week, with a strong Low over Hudson Bay and depressed westerlies along the east coast, the Highs followed the southern track. In the second week, with trough development along the west coast accompanied by ridging over the Southeast and strong confluence over most of North America (fig. 6A), the Canadian Highs glanced off eastward north of the Great Lakes, with the principal

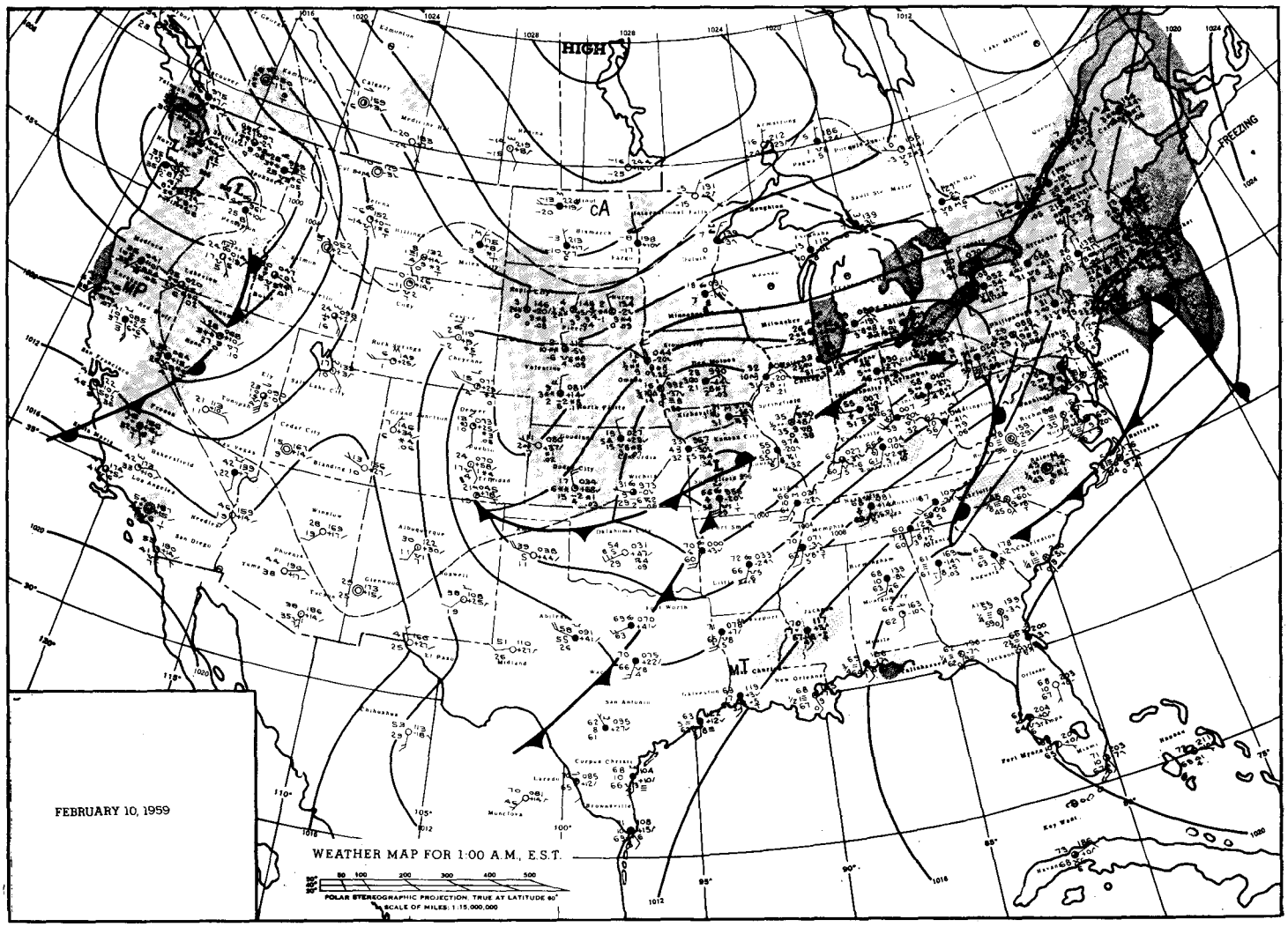


FIGURE 10.—Sea level weather map for 0100 EST February 10, 1959. Storm center in Missouri spawned St. Louis tornado about 2 hours after map time. Note the extreme warmth (near 70° F.) and moisture (dew points about 65° F.) in warm sector. Precipitation area north of front consisted largely of freezing rain. (From *Daily Weather Map*, U.S. Weather Bureau, Feb. 10, 1959.)

storm track from out of the Great Basin. In the third week, due to new trough development near the east coast, the tracks exhibited the influence of both east and west coast troughs, with some additional transitory influences in evidence. The fourth week's tracks were more zonal.

6. DAILY WEATHER SYSTEMS

Early in the first week a Canadian anticyclone developed to a record intensity of about 1053 mb. as it moved southeastward across the upper Mississippi Valley, producing record minimum temperatures at some stations such as Flint, Mich. (−18° F. and −22° F. on Feb. 1 and 2) and Nantucket, Mass. (8° F. minimum on the 2d). During midweek, cyclonic activity swept southeastward from Alberta toward the lower Great Lakes, then northeastward in the mean flow (fig. 5A), producing mostly moderate precipitation in the East. However heavy amounts fell in the Southeast due to wave activity on the polar front. Late in the week another anticyclone developed in the central part of the United States and crossed the Carolina coast at the weekend.

By the beginning of the second week there were abundant signs of an impending change in the large-scale regime. For example, the west coast ridge aloft and the eastern Pacific High cell had retrograded about 15° of longitude from their positions a week earlier to about 150° W., permitting cyclonic vorticity maxima to plunge southward along the west coast. This was manifested by a surface disturbance of the "A" type [5] in the western Great Basin. With 700-mb. heights increasing and temperatures warming to well above normal in the East as a result of trough development in the West, an Arctic anticyclone in Alberta glanced off eastward along the track north of the Great Lakes as did its successors in the same week (fig. 9). By the 9th the Great Basin disturbance had deepened to a storm in southwestern Colorado. With another deepening "A"-type system approaching the Oregon coast, the Colorado storm accelerated eastward across

the midsection of the country toward the Ohio Valley. This storm and its associated fronts produced the most severe weather of the month. Hourly wind speeds in many places along its path were well over 50 knots. For example, Roswell, N. Mex. on the 9th reported 68 knots, St. Louis, Mo., 66 knots, and Dayton, Ohio, 54 knots, on the 10th. In the dry, unstable, maritime polar air behind the first cold front dust storms developed in parts of the southern Plains such as Amarillo and Dallas, Tex. North of the sharp stationary front along which the storm raced toward Ohio, a widespread area of freezing rain occurred as extremely warm and moist tropical air in the warm sector overran the Arctic air north of the front. Moderate to heavy glazing on the 9th and 10th was reported at such stations as Topeka, Kans., St. Joseph, Mo., Rockford, Ill., Williamsport, Pa., Albany, N.Y., and Providence, R.I.

Figure 10, a reproduction of the published *Daily Weather Map*, for 0100 EST February 10, shows conditions at the surface about 2 hours before a devastating tornado hit St. Louis, Mo. This map shows the storm center just northwest of Springfield, Mo., where a tornado was also reported one hour earlier about 25 miles northwest of the city. The conditions depicted on this map closely resemble those for typical tornado cases [6] which show a confluence of extremely moist tropical air, dry maritime polar air, and continental polar air into a deep storm center (about 992 mb. minimum pressure was recorded at St. Louis) with a cyclonic speed maximum at upper levels (not shown).

Flood conditions revisited Indiana and Ohio as a result of heavy rains falling on frozen ground on the 9th and 10th, after less than a month's respite from floods in January. Some places experienced the worst flood conditions since 1913. Hard hit areas were the Wabash and Maumee Rivers in Indiana and the Sandusky in Ohio. Such cities as Fort Wayne, Ind., and Toledo, Sandusky, Fremont, Dayton, Akron, Cleveland, and Youngstown, Ohio, reported various degrees of flooding with evacuation and heavy damage in some areas.

This storm passed rapidly off the middle Atlantic coast on the 10th, setting maximum temperature records at Washington, D.C., Augusta, Ga., Norfolk, and Richmond, Va. The anticyclone which followed in its wake brought a record minimum of −4° F. to Schenectady, N.Y. on the 12th.

During this period another disturbance was traversing the Great Basin from the 10th to the 13th. This storm produced heavy snows in the West, over a foot at Olympia, Wash., almost 3 feet at Blue Canyon, Calif., 22 inches at Reno, Nev., and a record 7.7 inches at Ely, Nev. This system, in contrast to its predecessor, remained weak while crossing the middle of the United States, but deepened markedly on the 14th as it passed off the New England coast. Late in this week a third deep storm plunged southeastward from Alaska, lashing the Pacific Northwest, and producing heavy snows at higher elevations. Record 24-hr. amounts of 22.6 inches were reported at Sexton Summit, Oreg. on the 13th and 14th, and 28 inches at Mt. Shasta, Calif. This system was forced inland on a track across Canada toward Hudson Bay on the 15th, in contrast to the prevailing storm track of the second week across the midsection of the United States.

On the 16th and 17th a secondary disturbance was forming over the southern Plains, accompanied by a record maximum temperature for the date of 87° F. at Dallas, Tex. At the same time the coldest anticyclone of the month developed in western Canada due to the recurvature of the upper anticyclone in the Gulf of Alaska, and started to inch southward toward the northern Rockies and Great Plains. Over-running of the Arctic front by Pacific air produced about a foot of snow in parts of Montana such as Great Falls and Helena on the 16th and 17th. The disturbance which originated in the southern Plains started to develop strongly near the Carolina coast on the 18th, and became the center of action near Labrador in the mean circulation of the third week, thus effecting retrogression of the mean trough to the east coast. This development was in part a response to the strong buildup of pressure in western Canada that followed development of a major storm off the Oregon coast three days earlier. The Yukon ridge deployed Arctic air southeastward over the United States, producing record minimum temperatures at such places as North Platte, Nebr., with −19° F. on the 20th, and Birmingham, Ala., with 18° F. on the 21st, and it also permitted shorter wave spacing from coast to coast due to reduction of the westerlies. The storm that dominated the eastern Pacific off the Oregon coast during the 3d week deepened to about 960 mb. on the 16th after migrating northeastward from the Hawaiian area on the previous three days. It remained stationary off the coast for the remainder of the week and filled slowly as the blocking High recurving eastward farther north kept it cut off. This storm produced the mean Low off the Pacific Northwest coast in figure 7A.

During the last week a ridge replaced the Pacific coastal trough, ending the abundant precipitation regime of the middle two weeks of the month in the West. At the same time the polar vortex became entrenched near the Canadian archipelago, strengthening the westerlies across North America and favoring progression of the large-scale upper waves. Early in the week the last Great Basin disturbance emerged on the 22d, deepening and crossing the Great Lakes region as it headed for the New England coast. This storm produced about ½ to 1 inch of rain with some flooding reported in Rockford, Ill., and heavy snow in the Northeast. It was followed by a Pacific anticyclone and little weather of any significance during the remainder of the month.

REFERENCES

1. L. P. Stark, "The Weather and Circulation of January 1959—A Month of Exceptional Persistence from the Preceding December," *Monthly Weather Review*, vol. 87, No. 1, Jan. 1958, pp. 33–39.
2. W. H. Klein, "The Weather and Circulation of February 1958—A Month with an Expanded Circumpolar Vortex of Record Intensity," *Monthly Weather Review*, vol. 86, No. 2, Feb. 1958, pp. 60–70.
3. C. M. Woffinden, "The Weather and Circulation of February 1957—Another February with a Pronounced Index Cycle and Temperature Reversal over the United States," *Monthly Weather Review*, vol. 85, No. 2, Feb. 1957, pp. 53–61.
4. W. H. Klein, "Principal Tracks and Mean Frequencies of Cyclones and Anticyclones in the Northern Hemisphere," U.S. Weather Bureau, *Research Paper* No. 40, Washington, D.C., 1957.
5. R. D. Elliot, "Weather Types of North America," *Weatherwise*, vol. 2, Nos. 1–6, Feb.–Dec. 1949.
6. Staff Members, Severe Local Storms Forecast Center, Kansas City, Mo., "Forecasting Tornadoes and Severe Thunderstorms," U.S. Weather Bureau, *Forecasting Guide* No. 1, Washington, D.C., Sept. 1956. (See pp. 22–24.)

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